# Codes and Standards
# Title 24 Energy-Efficient Local Ordinances

## Title:
## Climate Zone 4
## Energy Cost-Effectiveness Study

**Prepared for:**

Pat Eilert
Codes and Standards Program
Pacific Gas and Electric Company

Maril Pitcock
Government Partnership Program
Pacific Gas and Electric Company

**Prepared by:**
Gabel Associates, LLC

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Report prepared by:
Michael Gabel of Gabel Associates, LLC
1818 Harmon Street, Suite #1 Berkeley, CA 94703
(510) 428-0803  Email: mike@gabelenergy.com

Report on behalf of:
Pacific Gas and Electric Company's Codes and Standards Program,
Pat Eilert, 202 Cousteau Place, Davis, CA 95616
(530) 757-5261  Email: PLE2@pge.com

Pacific Gas and Electric Company's Government Partnership Program,
Maril Pitcock, 245 Market, San Francisco, Room 687, CA 94105
(415) 973-9944  Email: MxWL@pge.com

## LEGAL NOTICE

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# 1.0 Executive Summary

This report presents the results of Gabel Associates' research and review of the feasibility and energy cost-effectiveness of building permit applicants exceeding the 2008 Building Energy Efficiency Standards to meet the minimum energy-efficiency requirements of local energy efficiency standards covering Climate Zone 4. A local government may use this report as a basis for demonstrating energy cost-effectiveness of a proposed green building or energy ordinance. The study assumes that such an ordinance requires, for the building categories covered, that building energy performance exceeds the 2008 TDV energy standard budget by at least 15%.

The study is also contained in the local government's application to the California Energy Commission (CEC) which must meet all requirements specified in Section 10-106 of the California Code of Regulations, Title 24, Part 1, Article 1: Locally Adopted Energy Standards. An ordinance shall be legally enforceable (a) after the CEC has reviewed and approved the local energy standards as meeting all requirements of Section 10-106; and (b) the ordinance has been adopted by the local government and filed with the Building Standards Commission.

The 2008 Building Energy Efficiency Standards, which took effect on January 1, 2010, are the baseline used to calculate the cost-effectiveness data.

## 2.0 Methodology and Assumptions

The energy performance impacts of exceeding the performance requirements of the 2008 Title 24 Building Energy Efficiency Standards (2008 Standards) have been evaluated in Climate Zone 4 using the following residential and nonresidential prototypical building types:

| | |
|---|---|
| **Small Single Family House**<br>2-story<br>2,025 sf | **Large Single Family House**<br>2-story<br>4,500 sf |
| **Low-rise Multi-family Apartments**<br>8 dwelling units/2-story<br>8,442 sf | **High-rise Multi-family Apartments**<br>40 dwelling units/4-story<br>36,800 sf |
| **Low-rise Office Building**<br>1-story<br>10,580 sf | **High-rise Office Building**<br>5-story<br>52,900 sf |

### Methodology

The methodology used in the case studies is based on a design process for each of the proposed prototypical building types that first meets the minimum requirements and then exceeds the 2008 Standards by 15%. The process includes the following major stages:

***Stage 1: Minimum Compliance with 2008 Standards:***

Each prototype building design is tested for minimum compliance with the 2008 Standards, and the mix of energy measures are adjusted using common construction options so the building first just meets the Standards. The set of energy measures chosen represent a reasonable combination which reflects how designers, builders and developers are likely to achieve a specified level of performance using a relatively low first incremental (additional) cost.

***Stage 2: Incremental Cost for Exceeding 2008 Standards by 15%:***

Starting with that set of measures which is minimally compliant with the 2008 Standards, various energy measures are upgraded so that the building just exceeds the 2008 Standards by 15%. The design choices by the consultant authoring this study are based on many years of experience with architects, builders, mechanical engineers; and general knowledge of the relative acceptance and preferences of many measures, as well as their incremental costs. This approach tends to reflect how building energy performance is typically evaluated for code compliance and how it's used to select design energy efficiency measures. Note that lowest simple payback with respect to building site energy is not the primary focus of selecting measures; but rather the requisite reduction of Title 24 Time Dependent Valuation(TDV) energy at a reasonable incremental cost consistent with other non-monetary but important design considerations. A minimum and

maximum range of incremental costs of added energy efficiency measures is established by a variety of research means. A construction cost estimator, Building Advisory LLC, was contracted to conduct research to obtain current measure cost information for many energy measures; and Gabel Associates performed its own additional research to establish first cost data.

***Stage 3: Cost Effectiveness Determination:***

Energy savings in kWh and therms is calculated from the Title 24 simulation results to establish the annual energy cost savings and $CO_2$-equivalent reductions in greenhouse gases. A simple payback analysis in years is calculated by dividing the incremental cost for exceeding the 2008 Standards by the estimated annual energy cost savings.

## Assumptions

### *Annual Energy Cost Savings*

1. Annual site electricity (kWh) and natural gas (therms) saved are calculated using Micropas 8, state-approved energy compliance software for the 2008 Building Energy Efficiency Standards.

2. Average residential utility rates of $0.18/kWh for electricity and $1.15/therm for natural gas in current constant dollars; nonresidential rates are time-of-use rate schedules modeled explicitly in the DOE-2.1E computer simulation: PG&E A-6 schedule for electricity and PG&E G-NR1 schedule for natural gas.

3. No change (i.e., no inflation or deflation) of utility rates in constant dollars

4. No increase in summer temperatures from global climate change

### *Simple Payback Analysis*

1. No external cost of global climate change -- and corresponding value of additional investment in energy efficiency and $CO_2$ reduction – is included

2. The cost of money (e.g., opportunity cost) invested in the incremental cost of energy efficiency measures is not included.

## 3.0 Minimum Compliance with 2008 Standards

The following energy design descriptions of the following building prototypes just meet the 2008 Standards in Climate Zone 4.

**Small Single Family House**

- 2,025 square feet
- 2-story
- 20.2% glazing/floor area ratio

Base Case with No Air Conditioning

| Energy Efficiency Measures |
|---|
| R-38 Roof w/ Radiant Barrier |
| R-13 Walls |
| R-19 Raised Floor over Garage/Open at 2nd Floor |
| R-0 Slab on Grade |
| Low E2 Vinyl Windows, U=0.36, SHGC=0.30 |
| Furnace: 80% AFUE |
| Air Conditioner: None |
| R-6 Attic Ducts |
| 50 Gallon Gas Water Heater: EF=0.62 |

Base Case With Air Conditioning

| Energy Efficiency Measures |
|---|
| R-38 Roof w/ Radiant Barrier |
| R-13 Walls |
| R-19 Raised Floor over Garage/Open at 2nd Floor |
| R-0 Slab on Grade |
| Low E2 Vinyl Windows, U=0.36, SHGC=0.30 |
| Furnace: 80% AFUE |
| Air Conditioner: 13 SEER |
| R-6 Attic Ducts |
| 50 Gallon Gas Water Heater: EF=0.62 |

**Large Single Family House**

- 4,500 square feet
- 2-story
- 22.0% glazing/floor area ratio

Base Case with No Air Conditioning

| Energy Efficiency Measures |
|---|
| R-38 Roof w/ Radiant Barrier |
| R-13 Walls |
| R-19 Raised Floor |
| Low E2 Vinyl Windows, U=0.36, SHGC=0.30 |
| (2) Furnaces: 80% AFUE |
| Air Conditioner: None |
| R-6 Attic Ducts |
| Reduced Duct Leakage/Testing (HERS) |
| (2) 50 Gallon Gas Water Heaters: EF=0.62 |

Base Case With Air Conditioning

| Energy Efficiency Measures |
|---|
| R-38 Roof w/ Radiant Barrier |
| R-13 Walls |
| R-19 Raised Floor |
| Low E2 Vinyl Windows, U=0.36, SHGC=0.30 |
| (2) Furnaces: 80% AFUE |
| (2) Air Conditioners: 13 SEER |
| R-6 Attic Ducts |
| Reduced Duct Leakage/Testing (HERS) |
| (2) 50 Gallon Gas Water Heaters: EF=0.62 |

**Low-rise Multi-family Apartments**

- 8,442 square feet
- 8 units/2-story
- 12.5% glazing/floor area ratio

Base Case with No Air Conditioning

| Energy Efficiency Measures |
|---|
| R-19 Roof w/ Radiant Barrier |
| R-13 Walls |
| R-0 Slab on Grade |
| Low E2 Vinyl Windows, U=0.36, SHGC=0.30 |
| (8) Furnaces: 80% AFUE |
| Air Conditioner: None |
| R-6 Attic Ducts |
| (8) 40 Gallon Gas Water Heaters: EF=0.63 |

Base Case With Air Conditioning

| Energy Efficiency Measures |
|---|
| R-19 Roof w/ Radiant Barrier |
| R-13 Walls |
| R-0 Slab on Grade |
| Low E2 Vinyl Windows, U=0.36, SHGC=0.30 |
| (8) Furnaces: 80% AFUE |
| (8) Air Conditioner: 13 SEER |
| R-6 Attic Ducts |
| (8) 40 Gallon Gas Water Heaters: EF=0.63 |

## High-rise Multifamily Apartments

- 36,800 sf,
- 40 units
- 4-story
- Window to Wall Ratio = 35.2%

| Energy Efficiency Measures to Meet Title 24 |
|---|
| R-19 Metal Roof w/ R-19 batt insulation below; no cool roof |
| R-19 in Metal Frame Walls |
| R-4 (1.25") Raised Slab over parking garage |
| Dual Metal Windows: COG U-factor=0.30, COG SHGC=0.54 |
| 1.5 ton 4-pipe fan coils, 80% AFUE boiler, 70-ton scroll air cooled chiller 0.72 KW/ton |
| Central DHW boiler: 80% AFUE and recirculating system w/ timer-temperature controls |

## Low-rise Office Building

- Single Story
- 10,580 sf,
- Window to Wall Ratio = 37.1%

| Energy Efficiency Measures to Meet Title 24 |
|---|
| R-19 Metal Roof w/ R-19 batt below; no cool roof |
| R-19 in Metal Frame Walls |
| R-0 (un-insulated) slab-on-grade 1st floor |
| Metal windows: default glazing U=0.71, default SHGC=0.73 |
| Lighting = 0.858 w/sf: Open Office Areas: (60) 2-lamp T8 fixtures @58w each; (24) 18w recessed CFLs no lighting controls. Small Offices: (48) 2-lamp T8 fixtures; (40) 18w recessed CFLs, no controls. Support Areas: (32) 18w recessed CFLs; (48) 13w CFL wall sconces; no controls. |
| (2) 13-ton DX units EER=11.6; 82% AFUE furnaces; standard efficiency fan motors; fixed temp. integrated air economizers |
| R-6 duct insulation w/ ducts on roof, HERS verified duct leakage |
| (1) 50 gallon or less tank Gas Water Heaters EF=0.58 |

**High-rise Office Building**

- 5-story
- 52,900 sf,
- Window to Wall Ratio = 34.5%

| Energy Efficiency Measures to Meet Title 24 |
|---|
| R-19 Metal Roof; no cool roof |
| R-19 in Metal Frame Walls |
| R-0 (un-insulated) slab-on-grade 1st floor |
| Metal windows: default U=0.71, default SHGC=0.73 |
| Lighting = 0.858 w/sf: Open Office Areas: (300) 2-lamp T8 fixtures @58w each; no lighting controls; (120) 18w recessed CFLs no lighting controls. Small Offices: (280) 2-lamp T8 fixtures on/off lighting controls; (200) 18w recessed CFLs no lighting controls. Support Areas: (160) 18w recessed CFLs no lighting controls; (240) 13w CFL wall sconces; no lighting controls. |
| (4) 55-ton Packaged VAV EER=10.1; 80% TE furnaces; standard efficiency variable speed fan motors; no air economizers; 15% VAV boxes, electric reheat on perimeter zones |
| R-6 duct insulation w/ ducts in conditioned |
| Standard Tank Gas Water Heaters EF=0.58 |

## 4.0 Incremental Cost to Exceed 2008 Standards by 15%

The following tables list the energy features and/or equipment included in the 2008 Standards base design, the efficient measure options, and an estimate of the incremental cost for each measure included **to improve the building performance to use 15% less TDV energy than the corresponding Title 24 base case design**.

### Small Single Family House

- 2,025 square feet
- 2-story
- 20.2% glazing/floor area ratio

**Incremental Cost Estimate to Exceed Title 24 by 15%**
**Single Family Prototype: 2,025 SF, Option 1 - No AC** **2025 sf** **Climate Zone 4**

| Energy Efficiency Measures | Change Type | Incremental Cost Estimate | | |
|---|---|---|---|---|
| | | Min | Max | Avg |
| R-30 Roof w/ Radiant Barrier (from R-38 w/Radiant Barrier): 1,443 sf @ 0.15 to 0.20/sf | Downgrade | $ (289) | $ (216) | $ (253) |
| R-19 Walls (from R-13): 2,550 sf @$0.31 to $0.54/sf | Upgrade | $ 791 | $ 1,377 | $ 1,084 |
| R-19 Raised Floor over Garage/Open at 2nd Floor | - | $ - | $ - | $ - |
| R-0 Slab on Grade | - | $ - | $ - | $ - |
| Low E2 Vinyl Windows, U=0.36, SHGC=0.30 | - | $ - | $ - | $ - |
| Furnace: 80% AFUE | - | $ - | $ - | $ - |
| Air Conditioner: None | - | $ - | $ - | $ - |
| R-4.2 Attic Ducts (from R-6) | Downgrade | $ (325) | $ (225) | $ (275) |
| Reduced Duct Leakage/Testing (HERS) | Upgrade | $ 300 | $ 600 | $ 450 |
| 50 Gallon Gas Water Heater: EF=0.62 | - | $ - | $ - | $ - |
| **Total Incremental Cost of Energy Efficiency Measures:** | | **$ 477** | **$ 1,536** | **$ 1,006** |
| **Total Incremental Cost per Square Foot:** | | **$ 0.24** | **$ 0.76** | **$ 0.50** |

**Incremental Cost Estimate to Exceed Title 24 by 15%**
**Single Family Prototype: 2,025 SF, Option 2 - No AC** **2025 sf** **Climate Zone 4**

| Energy Efficiency Measures | Change Type | Incremental Cost Estimate | | |
|---|---|---|---|---|
| | | Min | Max | Avg |
| R-38 Roof w/ Radiant Barrier | - | $ - | $ - | $ - |
| R-13 Walls | - | $ - | $ - | $ - |
| R-19 Raised Floor over Garage/Open at 2nd Floor | - | $ - | $ - | $ - |
| R-0 Slab on Grade | - | $ - | $ - | $ - |
| Low E2 Vinyl Windows, U=0.36, SHGC=0.30 | - | $ - | $ - | $ - |
| Furnace: 92% AFUE (from 80% AFUE) | Upgrade | $ 500 | $ 1,200 | $ 850 |
| Air Conditioner: None | - | $ - | $ - | $ - |
| R-8 Attic Ducts (from R-6) | Upgrade | $ 225 | $ 325 | $ 275 |
| Reduced Duct Leakage/Testing (HERS) | Upgrade | $ 300 | $ 600 | $ 450 |
| 50 Gallon Gas Water Heater: EF=0.62 | - | $ - | $ - | $ - |
| **Total Incremental Cost of Energy Efficiency Measures:** | | **$ 1,025** | **$ 2,125** | **$ 1,575** |
| **Total Incremental Cost per Square Foot:** | | **$ 0.51** | **$ 1.05** | **$ 0.78** |

**Incremental Cost Estimate to Exceed Title 24 by 15%**
**Single Family Prototype: 2,025 SF, Option 3 with AC** **2025 sf** **Climate Zone 4**

| Energy Efficiency Measures | Change Type | Incremental Cost Estimate | | |
|---|---|---|---|---|
| | | Min | Max | Avg |
| R-38 Roof w/ Radiant Barrier | - | $ - | $ - | $ - |
| R-19 Walls (from R-13): 2,550 sf @$0.31 to $0.54/sf | Upgrade | $ 791 | $ 1,377 | $ 1,084 |
| R-30 Raised Floor over Garage/Open at 2nd Floor (from R-19): 448 sf @ $0.25 to $0.35 | Upgrade | $ 112 | $ 157 | $ 134 |
| R-0 Slab on Grade | - | $ - | $ - | $ - |
| Low E2 Vinyl Windows, U=0.36, SHGC=0.30 | - | $ - | $ - | $ - |
| Furnace: 80% AFUE | - | $ - | $ - | $ - |
| Air Conditioner: 13 SEER, 11 EER (HERS) | Upgrade | $ 25 | $ 75 | $ 50 |
| Air Conditioner: Refrig. Charge (HERS) | Upgrade | $ 150 | $ 200 | $ 175 |
| R-8 Attic Ducts (from R-6) | Upgrade | $ 225 | $ 325 | $ 275 |
| 50 Gallon Gas Water Heater: EF=0.63 (from EF=0.62) | Upgrade | $ - | $ 50 | $ 25 |
| **Total Incremental Cost of Energy Efficiency Measures:** | | **$ 1,303** | **$ 2,184** | **$ 1,743** |
| **Total Incremental Cost per Square Foot:** | | **$ 0.64** | **$ 1.08** | **$ 0.86** |

**Incremental Cost Estimate to Exceed Title 24 by 15%**
**Single Family Prototype: 2,025 SF, Option 4 with AC** **2025 sf** **Climate Zone 4**

| Energy Efficiency Measures | Change Type | Incremental Cost Estimate | | |
|---|---|---|---|---|
| | | Min | Max | Avg |
| R-30 Roof w/ Radiant Barrier (from R-38 w/Radiant Barrier): 1,443 sf @ 0.15 to 0.20/sf | Downgrade | $ (289) | $ (216) | $ (253) |
| R-21 Walls (from R-13): 2,550 sf @ $0.45 to $0.70/sf | Upgrade | $ 1,148 | $ 1,785 | $ 1,466 |
| R-30 Raised Floor over Garage/Open at 2nd Floor (from R-19): 448 sf @ $0.25 to $0.35 | Upgrade | $ 112 | $ 157 | $ 134 |
| R-0 Slab on Grade | - | $ - | $ - | $ - |
| Low E2 Vinyl Windows, U=0.36, SHGC=0.30 | - | $ - | $ - | $ - |
| Furnace: 80% AFUE | - | $ - | $ - | $ - |
| Air Conditioner: 13 SEER | - | $ - | $ - | $ - |
| R-8 Attic Ducts (from R-6) | Upgrade | $ 225 | $ 325 | $ 275 |
| 50 Gallon Gas Water Heater: EF=0.62 | - | $ - | $ - | $ - |
| **Total Incremental Cost of Energy Efficiency Measures:** | | **$ 1,196** | **$ 2,050** | **$ 1,623** |
| **Total Incremental Cost per Square Foot:** | | **$ 0.59** | **$ 1.01** | **$ 0.80** |

## Large Single Family House

- 4,500 square feet
- 2-story
- 22.0% glazing/floor area ratio

**Incremental Cost Estimate to Exceed Title 24 by 15%**
**Single Family Prototype: 4,500 SF, Option 1 - No AC** **4500 sf** **Climate Zone 4**

| Energy Efficiency Measures | Change Type | Incremental Cost Estimate | | |
|---|---|---|---|---|
| | | Min | Max | Avg |
| R-38 Roof w/ Radiant Barrier | - | $ - | $ - | $ - |
| R-21 Walls (from R-13): 2,518 sf @ $0.45 to $0.70/sf | Upgrade | $ 1,133 | $ 1,763 | $ 1,448 |
| R-30 Raised Floor (from R-19): 2,700 sf @ $0.25 to $0.35 | Upgrade | $ 675 | $ 945 | $ 810 |
| Low E2 Vinyl Windows, U=0.36, SHGC=0.30 | - | $ - | $ - | $ - |
| (2) Furnaces: 80% AFUE | - | $ - | $ - | $ - |
| Air Conditioner: None | - | $ - | $ - | $ - |
| R-8 Attic Ducts (from R-6) | Upgrade | $ 450 | $ 650 | $ 550 |
| Reduced Duct Leakage/Testing (HERS) | - | $ - | $ - | $ - |
| (2) 50 Gallon Gas Water Heaters: EF=0.63 (from EF=0.62) | Upgrade | $ - | $ 100 | $ 50 |
| Pipe Insulation | Upgrade | $ 300 | $ 400 | $ 350 |
| **Total Incremental Cost of Energy Efficiency Measures:** | | **$ 2,558** | **$ 3,858** | **$ 3,208** |
| **Total Incremental Cost per Square Foot:** | | **$ 0.57** | **$ 0.86** | **$ 0.71** |

**Incremental Cost Estimate to Exceed Title 24 by 15%**
**Single Family Prototype: 4,500 SF, Option 2 - No AC** **4500 sf** **Climate Zone 4**

| Energy Efficiency Measures | Change Type | Incremental Cost Estimate | | |
|---|---|---|---|---|
| | | Min | Max | Avg |
| R-38 Roof w/ Radiant Barrier | - | $ - | $ - | $ - |
| R-19 Walls (from R-13): 2,518 sf @ $0.31 to $0.54/sf | Upgrade | $ 781 | $ 1,360 | $ 1,070 |
| R-19 Raised Floor | - | $ - | $ - | $ - |
| Low E2 Vinyl Windows, U=0.36, SHGC=0.30 | - | $ - | $ - | $ - |
| (2) Furnaces: 92% AFUE (from 80% AFUE) | Upgrade | $ 1,000 | $ 2,400 | $ 1,700 |
| Air Conditioner: None | - | $ - | $ - | $ - |
| R-6 Attic Ducts | - | $ - | $ - | $ - |
| Reduced Duct Leakage/Testing (HERS) | - | $ - | $ - | $ - |
| (2) 50 Gallon Gas Water Heaters: EF=0.63 (from EF=0.62) | Upgrade | $ - | $ 100 | $ 50 |
| **Total Incremental Cost of Energy Efficiency Measures:** | | **$ 1,781** | **$ 3,860** | **$ 2,820** |
| **Total Incremental Cost per Square Foot:** | | **$ 0.40** | **$ 0.86** | **$ 0.63** |

**Incremental Cost Estimate to Exceed Title 24 by 15%**
**Single Family Prototype: 4,500 SF, Option 3 with AC** **4500 sf** **Climate Zone 4**

| Energy Efficiency Measures | Change | Incremental Cost Estimate | | |
|---|---|---|---|---|
| R-30 Roof w/ Radiant Barrier (from R-38 w/ Radiant Barrier): 2,700 sf @ 0.15 to 0.20/sf | Downgrade | $ (540) | $ (405) | $ (473) |
| R-19 Walls (from R-13): 2,518 sf @ $0.31 to $0.54/sf | Upgrade | $ 781 | $ 1,360 | $ 1,070 |
| R-19 Raised Floor | - | $ - | $ - | $ - |
| Low E2 Vinyl Windows, U=0.36, SHGC=0.30 | - | $ - | $ - | $ - |
| (2) Furnaces: 80% AFUE | - | $ - | $ - | $ - |
| Air Conditioner: 13 SEER, 11 EER (HERS) | Upgrade | $ 50 | $ 150 | $ 100 |
| R-4.2 Attic Ducts (from R-6) | Downgrade | $ (450) | $ (650) | $ (550) |
| Reduced Duct Leakage/Testing (HERS) | - | $ - | $ - | $ - |
| (2) Instantaneous Gas Water Heaters: RE=0.80 (from 50 Gal Gas: EF=0.62) | Upgrade | $ 1,800 | $ 3,000 | $ 2,400 |
| **Total Incremental Cost of Energy Efficiency Measures:** | | **$ 1,641** | **$ 3,455** | **$ 2,548** |
| **Total Incremental Cost per Square Foot:** | | **$ 0.36** | **$ 0.77** | **$ 0.57** |

**Incremental Cost Estimate to Exceed Title 24 by 15%**
**Single Family Prototype: 4,500 SF, Option 4 with AC** **4500 sf** **Climate Zone 4**

| Energy Efficiency Measures | Change | Incremental Cost Estimate | | |
|---|---|---|---|---|
| R-38 Roof w/ Radiant Barrier | - | $ - | $ - | $ - |
| R-15 Walls (from R-13): 2,518 sf @ $0.14 to $0.18/sf | Upgrade | $ 353 | $ 453 | $ 403 |
| R-30 Raised Floor (from R-19): 2,700 sf @ $0.25 to $0.35 | Upgrade | $ 675 | $ 945 | $ 810 |
| Low E2 Vinyl Windows, U=0.36, SHGC=0.30 | - | $ - | $ - | $ - |
| (2) Furnaces: 80% AFUE | - | $ - | $ - | $ - |
| Air Conditioner: 13 SEER, 11 EER (HERS) | Upgrade | $ 50 | $ 150 | $ 100 |
| R-6 Attic Ducts | - | $ - | $ - | $ - |
| Reduced Duct Leakage/Testing (HERS) | - | $ - | $ - | $ - |
| (2) Instantaneous Gas Water Heaters: RE=0.82 (from 50 Gal Gas: EF=0.62) | Upgrade | $ 2,200 | $ 3,600 | $ 2,900 |
| **Total Incremental Cost of Energy Efficiency Measures:** | | **$ 3,278** | **$ 5,148** | **$ 4,213** |
| **Total Incremental Cost per Square Foot:** | | **$ 0.73** | **$ 1.14** | **$ 0.94** |

## Low-rise Multi-family Apartments

- 8,442 square feet
- 8 units/2-story
- 12.5% glazing/floor area ratio

**Incremental Cost Estimate to Exceed Title 24 by 15%**
**Multi-Family Prototype: 8,442 SF, Option 1 - No AC** **8442 sf** **Climate Zone 4**

| Energy Efficiency Measures | Change Type | Incremental Cost Estimate | | |
|---|---|---|---|---|
| | | Min | Max | Avg |
| R-30 Roof w/ Radiant Barrier (from R-19 w/Radiant Barrier): 4,221 sf @ 0.25 to 0.35/sf | Upgrade | $ 1,055 | $ 1,477 | $ 1,266 |
| R-21 Walls (from R-13 ): 10,146 sf @ $0.45 to $0.70/sf | Upgrade | $ 4,566 | $ 7,102 | $ 5,834 |
| R-0 Slab on Grade | - | $ - | $ - | $ - |
| Low E2 Vinyl, U=0.36, SHGC=0.30 | - | $ - | $ - | $ - |
| (8) Furnaces: 80% AFUE | - | $ - | $ - | $ - |
| Air Conditioner: None | - | $ - | $ - | $ - |
| R-6 Attic Ducts | - | $ - | $ - | $ - |
| (8) 40 Gallon Gas Water Heaters: EF=0.63 | - | $ - | $ - | $ - |
| **Total Incremental Cost of Energy Efficiency Measures:** | | **$ 5,621** | **$ 8,580** | **$ 7,100** |
| **Total Incremental Cost per Square Foot:** | | **$ 0.67** | **$ 1.02** | **$ 0.84** |

**Incremental Cost Estimate to Exceed Title 24 by 15%**
**Multi-Family Prototype: 8,442 SF, Option 2 - No AC** **8442 sf** **Climate Zone 4**

| Energy Efficiency Measures | Change Type | Incremental Cost Estimate | | |
|---|---|---|---|---|
| | | Min | Max | Avg |
| R-19 Roof w/ Radiant Barrier | - | $ - | $ - | $ - |
| R-19 Walls (from R-13 ): 10,146 sf @ $0.31 to $0.54/sf | Upgrade | $ 3,145 | $ 5,479 | $ 4,312 |
| R-0 Slab on Grade | - | $ - | $ - | $ - |
| Low E2 Vinyl, U=0.36, SHGC=0.30 | - | $ - | $ - | $ - |
| (8) Furnaces: 80% AFUE | - | $ - | $ - | $ - |
| Air Conditioner: None | - | $ - | $ - | $ - |
| R-4.2 Attic Ducts (from R-6) | Downgrade | $ (1,600) | $ (1,000) | $ (1,300) |
| Reduced Duct Leakage/Testing (HERS) | Upgrade | $ 2,400 | $ 4,800 | $ 3,600 |
| (8) 40 Gallon Gas Water Heaters: EF=0.62 (from EF=0.63) | Downgrade | $ (400) | $ - | $ (200) |
| **Total Incremental Cost of Energy Efficiency Measures:** | | **$ 3,545** | **$ 9,279** | **$ 6,412** |
| **Total Incremental Cost per Square Foot:** | | **$ 0.42** | **$ 1.10** | **$ 0.76** |

**Incremental Cost Estimate to Exceed Title 24 by 15%**
**Multi-Family Prototype: 8,442 SF, Option 3 with AC** **8442 sf** **Climate Zone 4**

| Energy Efficiency Measures | Change Type | Incremental Cost Estimate | | |
|---|---|---|---|---|
| | | Min | Max | Avg |
| R-19 Roof w/ Radiant Barrier | - | $ - | $ - | $ - |
| R-21 Walls (from R-13 ): 10,146 sf @ $0.45 to $0.70/sf | Upgrade | $ 4,566 | $ 7,102 | $ 5,834 |
| R-0 Slab on Grade | - | $ - | $ - | $ - |
| Low E2 Vinyl, U=0.36, SHGC=0.30 | - | $ - | $ - | $ - |
| (8) Furnaces: 80% AFUE | - | $ - | $ - | $ - |
| (8) Air Conditioners: 13 SEER, 11 EER (HERS) | Upgrade | $ 200 | $ 600 | $ 400 |
| (8) Air Conditioner: Refrig. Charge (HERS) | Upgrade | $ 1,200 | $ 1,600 | $ 1,400 |
| R-8 Attic Ducts (from R-6) | Upgrade | $ 1,000 | $ 1,600 | $ 1,300 |
| (8) 40 Gallon Gas Water Heaters: EF=0.63 | - | $ - | $ - | $ - |
| **Total Incremental Cost of Energy Efficiency Measures:** | | **$ 6,966** | **$ 10,902** | **$ 8,934** |
| **Total Incremental Cost per Square Foot:** | | **$ 0.83** | **$ 1.29** | **$ 1.06** |

**Incremental Cost Estimate to Exceed Title 24 by 15%**
**Multi-Family Prototype: 8,442 SF, Option 4 with AC** **8442 sf** **Climate Zone 4**

| Energy Efficiency Measures | Change Type | Incremental Cost Estimate | | |
|---|---|---|---|---|
| | | Min | Max | Avg |
| R-19 Roof w/ Radiant Barrier | - | $ - | $ - | $ - |
| R-19 Walls (from R-13 ): 10,146 sf @ $0.31 to $0.54/sf | Upgrade | $ 3,145 | $ 5,479 | $ 4,312 |
| R-0 Slab on Grade | - | $ - | $ - | $ - |
| Low E2 Vinyl, U=0.36, SHGC=0.30 | - | $ - | $ - | $ - |
| (8) Furnace: 92% AFUE (from 80% AFUE) | Upgrade | $ 4,000 | $ 9,600 | $ 6,800 |
| Air Conditioner: None | - | $ - | $ - | $ - |
| R-4.2 Attic Ducts (from R-6) | Downgrade | $ (1,600) | $ (1,000) | $ (1,300) |
| (8) 40 Gallon Gas Water Heaters: EF=0.63 | - | $ - | $ - | $ - |
| **Total Incremental Cost of Energy Efficiency Measures:** | | **$ 5,545** | **$ 14,079** | **$ 9,812** |
| **Total Incremental Cost per Square Foot:** | | **$ 0.66** | **$ 1.67** | **$ 1.16** |

## High-rise Multifamily Apartments

- 36,800 sf,
- 40 units/4-story
- Window to Wall Ratio = 31.6%

**Incremental Cost Estimate to Exceed Title 24 by 15%**
**High-rise Residential Prototype: 36,800 SF, Option 1** **Climate Zone 4**

| Energy Efficiency Measures to Exceed Title 24 by 15% | Change Type | Incremental Cost Estimate | | |
|---|---|---|---|---|
| | | Min | Max | Avg |
| R-19 Metal Roof w/ **R-30 batt insulation below; Cool Roof Reflectance=0.55, Emittance=0.75**; 9,200 sf @ $0.50 - $0.70/sf | Upgrade | $ 4,600 | $ 6,440 | $ 5,520 |
| R-19 in Metal Frame Walls | - | | | |
| R-4 (1.25" K-13 spray-on) Raised Slab over parking garage | - | | | |
| Dual Metal Windows: COG U-factor=0.30**, COG SHGC=0.31** 6,240 sf @ $1.00 to $1.50/sf | Upgrade | $ 6,240 | $ 9,360 | $ 7,800 |
| 1.5 ton 4-pipe fan coils, **98% AFUE boiler**, 70-ton scroll air cooled chiller 0.72 KW/ton | Upgrade | $ 2,500 | $ 4,000 | $ 3,250 |
| Central DHW boiler: **98% AFUE** and recirculating system w/ timer-temperature controls | Upgrade | $ 2,500 | $ 4,000 | $ 3,250 |
| **Total Incremental Cost of Energy Efficiency Measures:** | | **$ 15,840** | **$ 23,800** | **$ 19,820** |
| **Total Incremental Cost per Square Foot:** | | **$ 0.43** | **$ 0.65** | **$ 0.54** |

**Incremental Cost Estimate to Exceed Title 24 by 15%**
**High-rise Residential Prototype: 36,800 SF, Option 2** **Climate Zone 4**

| Energy Efficiency Measures to Exceed Title 24 by 15% | Change Type | Incremental Cost Estimate | | |
|---|---|---|---|---|
| | | Min | Max | Avg |
| R-19 Metal Roof w/ R-19 batt insulation below; **Cool Roof Reflectance=0.55, Emittance=0.75**; 9,200 sf @ $0.35 - $0.50/sf | Upgrade | $ 3,220 | $ 4,600 | $ 3,910 |
| R-19 in Metal Frame Walls | - | | | |
| R-4 (1.25" K-13 spray-on) Raised Slab over parking garage | - | | | |
| Dual Metal Windows: COG U-factor=0.3**, COG SHGC=0.27** 6,240 sf @ $1.50 to $2.50/sf | Upgrade | $ 9,360 | $ 23,000 | $ 16,180 |
| 1.5 ton 4-pipe fan coils, **98% AFUE boiler**, 70-ton scroll air cooled chiller 0.72 KW/ton | Upgrade | $ 2,500 | $ 4,000 | $ 3,250 |
| Central DHW boiler: **98% AFUE** and recirculating system w/ timer-temperature controls | Upgrade | $ 2,500 | $ 4,000 | $ 3,250 |
| **Total Incremental Cost of Energy Efficiency Measures:** | | **$ 17,580** | **$ 35,600** | **$ 26,590** |
| **Total Incremental Cost per Square Foot:** | | **$ 0.48** | **$ 0.97** | **$ 0.72** |

**Incremental Cost Estimate to Exceed Title 24 by 15%**
**High-rise Residential Prototype: 36,800 SF, Option 3** **Climate Zone 4**

| Energy Efficiency Measures to Exceed Title 24 by 15% | Change Type | Incremental Cost Estimate | | |
|---|---|---|---|---|
| | | Min | Max | Avg |
| R-19 Metal Roof w/ **R-30 batt insulation below; Cool Roof Reflectance=0.55, Emittance=0.75**; 9,200 sf @ $0.50 - $0.70/sf | Upgrade | $ 4,600 | $ 6,440 | $ 5,520 |
| R-19 in Metal Frame Walls | - | | | |
| R-4 (1.25" K-13 spray-on) Raised Slab over parking garage | - | | | |
| Dual Metal Windows: COG U-factor=0.3, **COG SHGC=0.27** 6,240 sf @ $1.50 to $2.50/sf | Upgrade | $ 9,360 | $ 23,000 | $ 16,180 |
| 1.5 ton 4-pipe fan coils, **94% AFUE boiler**, 70-ton scroll air cooled chiller 0.72 KW/ton | Upgrade | $ 1,500 | $ 2,500 | $ 2,000 |
| Central DHW boiler: **94% AFUE** and recirculating system w/ timer-temperature controls | Upgrade | $ 1,500 | $ 2,500 | $ 2,000 |
| **Total Incremental Cost of Energy Efficiency Measures:** | | **$ 16,960** | **$ 34,440** | **$ 25,700** |
| **Total Incremental Cost per Square Foot:** | | **$ 0.46** | **$ 0.94** | **$ 0.70** |

## Low-rise Office Building

- Single Story
- 10,580 sf,
- Window to Wall Ratio = 37.1%

**Incremental Cost Estimate to Exceed Title 24 by 15%**
**Nonresidential Prototype: 10,580 SF, Option 1** **Climate Zone 4**

| Energy Efficiency Measures to Exceed Title 24 by 15% | Change Type | Incremental Cost Estimate | | |
|---|---|---|---|---|
| | | Min | Max | Avg |
| R-19 Metal Roof w/ **R-22 batt insulation below;** 10,580 sf @ $0.10 - $0.15/sf | Upgrade | $ 1,058 | $ 1,587 | $ 1,323 |
| R-19 in Metal Frame Walls | - | $ - | $ - | $ - |
| R-0 (un-insulated) slab-on-grade 1st floor | - | $ - | $ - | $ - |
| Metal windows: **COG U=0.30, COG SHGC=0.54**; 3,200 sf @ $1.50 to $2.50/sf | Upgrade | $ 4,800 | $ 8,000 | $ 6,400 |
| Lighting = 0.692 w/sf: Open Office Areas: **(32) 2-lamp T8 fixtures @74w each**; no lighting controls; (24) 18w recessed CFLs. Small Offices: (56) 2-lamp T8 fixtures, **(28) multi-level ocupancy sensors @ $75 to $100 each;** (40) 18w recessed CFLs. Support Areas: (32) 18w recessed CFLs; (48) 13w CFL wall sconces; no controls. | Upgrade | $ 820 | $ 1,648 | $ 1,234 |
| (2) 13-ton DX units EER=11.6; 82% AFUE furnaces; standard efficiency fan motors; fixed temp. integrated air economizers | - | $ - | $ - | $ - |
| **R-8** duct insulation w/ ducts on roof, HERS verified duct leakage | Upgrade | $ 100 | $ 250 | $ 175 |
| (1) 50 gallon or less tank Gas Water Heaters EF=0.58 | - | $ - | $ - | $ - |
| **Total Incremental Cost of Energy Efficiency Measures:** | | **$ 6,778** | **$ 11,485** | **$ 9,132** |
| **Total Incremental Cost per Square Foot:** | | **$ 0.64** | **$ 1.09** | **$ 0.86** |

**Incremental Cost Estimate to Exceed Title 24 by 15%**
**Nonresidential Prototype: 10,580 SF, Option 2** **Climate Zone 4**

| Energy Efficiency Measures to Exceed Title 24 by 15% | Change Type | Incremental Cost Estimate | | |
|---|---|---|---|---|
| | | Min | Max | Avg |
| R-19 Metal Roof w/R-19 batt below; **Cool Roof Reflectance=0.55, Emittance=0.75;** 10,580 sf @ $0.35 - $0.50/sf | Upgrade | $ 3,703 | $ 5,290 | $ 4,497 |
| R-19 in Metal Frame Walls | - | $ - | $ - | $ - |
| R-0 (un-insulated) slab-on-grade 1st floor | - | $ - | $ - | $ - |
| Metal windows: **COG U=0.30, COG SHGC=0.38**; 3,200 sf @ $1.50 to $3.00/sf | Upgrade | $ 4,800 | $ 9,600 | $ 7,200 |
| Lighting = 0.858 w/sf: Open Office Areas: (60) 2-lamp T8 fixtures @58w each; (24) 18w recessed CFLs no lighting controls. Small Offices: (48) 2-lamp T8 fixtures; (40) 18w recessed CFLs, no controls. Support Areas: (32) 18w recessed CFLs; (48) 13w CFL wall sconces; no controls. | - | $ - | $ - | $ - |
| (2) 13-ton DX units EER=11.6; 82% AFUE furnaces; standard efficiency fan motors; fixed temp. integrated air economizers | - | $ - | $ - | $ - |
| R-6 duct insulation w/ ducts on roof, HERS verified duct leakage | - | $ - | $ - | $ - |
| (1) 50 gallon or less tank Gas Water Heaters EF=0.58 | - | $ - | $ - | $ - |
| **Total Incremental Cost of Energy Efficiency Measures:** | | **$ 8,503** | **$ 14,890** | **$ 11,697** |
| **Total Incremental Cost per Square Foot:** | | **$ 0.80** | **$ 1.41** | **$ 1.11** |

**Incremental Cost Estimate to Exceed Title 24 by 15%**

**Nonresidential Prototype: 10,580 SF, Option 3** **Climate Zone 4**

| Energy Efficiency Measures to Exceed Title 24 by 15% | Change Type | Incremental Cost Estimate | | |
|---|---|---|---|---|
| | | Min | Max | Avg |
| R-19 Metal Roof w/ **R-25 batt insulation below; Cool Roof Reflectance=0.55, Emittance=0.75;** 10,580 sf @ $0.55 - $0.80/sf | Upgrade | $ 5,819 | $ 8,464 | $ 7,142 |
| R-19 in Metal Frame Walls | - | $ - | $ - | $ - |
| R-0 (un-insulated) slab-on-grade 1st floor | - | $ - | $ - | $ - |
| Metal windows: **COG U=0.30, COG SHGC=0.54**; 3,200 sf @ $1.50 to $2.50/sf | Upgrade | $ 4,800 | $ 8,000 | $ 6,400 |
| Lighting = 0.783 w/sf: Open Office Areas: (60) 2-lamp T8 fixtures @58w each; no lighting controls; (24) 18w recessed CFLs. Small Offices: (56) 2-lamp T8 fixtures, **(28) multi-level ocupancy sensors @ $75 to $100 each;** (40) 18w recessed CFLs. Support Areas: (32) 18w recessed CFLs; (48) 13w CFL wall sconces; no controls. | Upgrade | $ 2,100 | $ 2,800 | $ 2,450 |
| (2) 13-ton DX units EER=11.6; 82% AFUE furnaces; standard efficiency fan motors; fixed temp. integrated air economizers | - | | | |
| **R-8** duct insulation w/ ducts on roof, HERS verified duct leakage | Upgrade | $ 100 | $ 250 | $ 175 |
| **(1) tankless Gas Water Heaters EF=0.84** | Upgrade | $ 1,400 | $ 2,200 | $ 1,800 |
| **Total Incremental Cost of Energy Efficiency Measures:** | | **$ 14,219** | **$ 21,714** | **$ 17,967** |
| **Total Incremental Cost per Square Foot:** | | **$ 1.34** | **$ 2.05** | **$ 1.70** |

## High-rise Office Building

- 5-story
- 52,900 sf,
- Window to Wall Ratio = 34.5%

**Incremental Cost Estimate to Exceed Title 24 by 15%**
**Nonresidential Prototype: 52,900 SF, Option 1** **Climate Zone 4**

| Energy Efficiency Measures to Exceed Title 24 by 15% | Change Type | Incremental Cost Estimate | | |
|---|---|---|---|---|
| | | Min | Max | Avg |
| R-19 Metal Roof **w/ R-19 batt below;** 10,580 sf @ $0.35 - $0.50/sf | Upgrade | $ 3,703 | $ 5,290 | $ 4,497 |
| R-19 in Metal Frame Walls | - | - | - | - |
| R-0 (un-insulated) slab-on-grade 1st floor | - | - | - | - |
| Metal windows: **COG U=0.30, COG SHGC=0.38**; 16,000 sf @ $1.50 to $3.00/sf | Upgrade | $ 24,000 | $ 48,000 | $ 36,000 |
| Lighting = 0.858 w/sf: Open Office Areas: (300) 2-lamp T8 fixtures @58w each; no lighting controls; (120) 18w recessed CFLs no lighting controls. Small Offices: (280) 2-lamp T8 fixtures on/off lighting controls; (200) 18w recessed CFLs no lighting controls. Support Areas: (160) 18w recessed CFLs no lighting controls; (240) 13w CFL wall sconces; no lighting controls. | - | - | - | - |
| (4) 55-ton Packaged VAV EER=10.1; 80% TE furnaces; standard efficiency variable speed fan motors; **Fixed temp. integrated air economizers**; 15% VAV boxes, electric reheat on perim. zones | Upgrade | $ 8,000 | $ 12,000 | $ 10,000 |
| R-6 duct insulation w/ ducts in conditioned | - | - | - | - |
| Standard Tank Gas Water Heaters EF=0.58 | - | - | - | - |
| **Total Incremental Cost of Energy Efficiency Measures:** | | **$ 35,703** | **$ 65,290** | **$ 50,497** |
| **Total Incremental Cost per Square Foot:** | | **$ 0.67** | **$ 1.23** | **$ 0.95** |

**Incremental Cost Estimate to Exceed Title 24 by 15%**
**Nonresidential Prototype: 52,900 SF, Option 2** **Climate Zone 4**

| Energy Efficiency Measures to Exceed Title 24 by 15% | Change Type | Incremental Cost Estimate | | |
|---|---|---|---|---|
| | | Min | Max | Avg |
| R-19 Metal Roof; no cool roof | - | - | - | - |
| R-19 in Metal Frame Walls | - | - | - | - |
| R-0 (un-insulated) slab-on-grade 1st floor | - | - | - | - |
| Metal windows: **COG U=0.30, COG SHGC=0.38**; 16,000 sf @ $1.50 to $3.00/sf | Upgrade | $ 24,000 | $ 48,000 | $ 36,000 |
| Lighting = 0.783 w/sf: Open Office Areas: (300) 2-lamp T8 fixtures @58w each; no lighting controls; (120) 18w recessed CFLs no lighting controls;. Small Offices: **(280) 2-lamp T8 fixtures with 140 multi-level sensors; @ $75 to $100 each;** (200) 18w recessed CFLs, with multi-level sensors. Support Areas: (160) 18w recessed CFLs; (240) 13w CFL wall sconces; no lighting controls. | Upgrade | $ 10,500 | $ 14,000 | $ 12,250 |
| (4) 55-ton Packaged VAV EER=10.1; 80% TE furnaces; standard efficiency variable speed fan motors; no air economizers; 15% VAV boxes, electric reheat on perimeter zones | Upgrade | $ 8,000 | $ 12,000 | $ 10,000 |
| R-6 duct insulation w/ ducts in conditioned | - | - | - | - |
| Standard Tank Gas Water Heaters EF=0.58 | - | - | - | - |
| **Total Incremental Cost of Energy Efficiency Measures:** | | **$ 42,500** | **$ 74,000** | **$ 58,250** |
| **Total Incremental Cost per Square Foot:** | | **$ 0.80** | **$ 1.40** | **$ 1.10** |

**Incremental Cost Estimate to Exceed Title 24 by 15%**

**Nonresidential Prototype: 52,900 SF, Option 3** **Climate Zone 4**

| Energy Efficiency Measures to Exceed Title 24 by 15% | Change Type | Incremental Cost Estimate | | |
|---|---|---|---|---|
| | | Min | Max | Avg |
| R-19 Metal Roof **w/R-19 batt below; Cool Roof Reflectance=0.55, Emittance=0.75;** 10,580 sf @ $0.70 - $1.00/sf | Upgrade | $ 7,406 | $ 10,580 | $ 8,993 |
| **R-21** in Metal Frame Walls; 24,580 sf @ 0.10 - $0.15/sf | Upgrade | $ 2,458 | $ 3,687 | $ 3,073 |
| R-0 (un-insulated) slab-on-grade 1st floor | - | - | - | - |
| Metal windows: **COG U=0.30, COG SHGC=0.54**; 16,000 sf @ $1.00 to $2.00/sf | Upgrade | $ 16,000 | $ 32,000 | $ 24,000 |
| Lighting = 0.783 w/sf: Open Office Areas: (300) 2-lamp T8 fixtures @58w each; no lighting controls; (120) 18w recessed CFLs no lighting controls;. Small Offices: **(280) 2-lamp T8 fixtures with 140 multi-level sensors; @ $75 to $100 each;** (200) 18w recessed CFLs, with multi-level sensors. Support Areas: (160) 18w recessed CFLs; (240) 13w CFL wall sconces; no controls. | Upgrade | $ 10,500 | $ 14,000 | $ 12,250 |
| (4) 55-ton Packaged VAV EER=10.1; 80% TE furnaces; standard efficiency variable speed fan motors; no air economizers; 15% VAV boxes, electric reheat on perimeter zones | - | - | - | - |
| R-6 duct insulation w/ ducts in conditioned | - | - | - | - |
| Standard Tank Gas Water Heaters **EF=0.62** | Upgrade | $ 750 | $ 1,500 | $ 1,125 |
| **Total Incremental Cost of Energy Efficiency Measures:** | | **$ 37,114** | **$ 61,767** | **$ 49,441** |
| **Total Incremental Cost per Square Foot:** | | **$ 0.70** | **$ 1.17** | **$ 0.93** |

## 5.0 Cost -Effectiveness Determination

Regardless of the building design, occupancy profile and number of stories, the incremental improvement in overall annual energy performance of buildings in exceeding the 2008 Standards is determined to be cost-effective. However, each building's overall design, occupancy type and specific design choices may allow for a large range of incremental costs for exceeding 2008 Standards, estimated annual energy cost savings, and subsequent payback period.

### Small Single Family

| Building Description | Total Annual KWh Saving | Total Annual Therms Saving | Incremental First Cost ($) | Annual Energy Cost Savings ($) | Simple Payback (Years) |
|---|---|---|---|---|---|
| 2,025 sf (Option 1) | 208 | 79 | $1,007 | $128 | 7.8 |
| 2,025 sf (Option 2) | 99 | 93 | $1,575 | $125 | 12.6 |
| 2,025 sf (Option 3) | 212 | 74 | $1,744 | $123 | 14.1 |
| 2,025 sf (Option 4) | 212 | 77 | $1,623 | $127 | 12.8 |
| Averages: | 183 | 81 | $1,487 | $126 | 11.9 |

***Annual Reduction in CO2-equivalent: 0.50 lb./sq.ft.-year; 1,022 lb./building-year***
***Increased Cost / lb. CO2-e reduction: $1.45***

### Large Single Family

| Building Description | Total Annual KWh Saving | Total Annual Therms Saving | Incremental First Cost ($) | Annual Energy Cost Savings ($) | Simple Payback (Years) |
|---|---|---|---|---|---|
| 4,500 sf (Option 1) | 320 | 100 | $3,208 | $173 | 18.6 |
| 4,500 sf (Option 2) | 228 | 113 | $2,821 | $171 | 16.5 |
| 4,500 sf (Option 3) | 140 | 130 | $2,548 | $175 | 14.6 |
| 4,500 sf (Option 4) | 87 | 140 | $4,213 | $177 | 23.8 |
| Averages: | 194 | 121 | $3,197 | $174 | 18.4 |

***Annual Reduction in CO2-equivalent: 0.33 lb./sq.ft.-year; 1,493 lb./building-year***
***Increased Cost / lb. CO2-e reduction: $2.14***

## Low-rise Multi-family Apartments

| Building Description | Total Annual KWh Saving | Total Annual Therms Saving | Incremental First Cost ($) | Annual Energy Cost Savings ($) | Simple Payback (Years) |
|---|---|---|---|---|---|
| 8-Unit, 8,442 sf (Option 1) | 1023 | 283 | $7,101 | $510 | 13.9 |
| 8-Unit, 8,442 sf (Option 2) | 998 | 286 | $6,412 | $509 | 12.6 |
| 8-Unit, 8,442 sf (Option 3) | 1015 | 264 | $8,934 | $486 | 18.4 |
| 8-Unit, 8,442 sf (Option 4) | 718 | 312 | $9,812 | $488 | 20.1 |
| Averages: | 939 | 286 | $8,065 | $498 | 16.3 |

***Annual Reduction in CO2-equivalent: 0.44 lb./sq.ft.-year; 3,754 lb./building-year***
***Increased Cost / lb. CO2-e reduction: $2.15***

## High-rise Multi-family Apartments

| Building Description | Total Annual KWh Saving | Total Annual Therms Saving | Incremental First Cost ($) | Annual Energy Cost Savings ($) | Simple Payback (Years) |
|---|---|---|---|---|---|
| 36,800 sf (Option 1) | 12335 | 550 | $19,820 | $9,654 | 2.1 |
| 36,800 sf (Option 2) | 13670 | 362 | $26,590 | $2,877 | 9.2 |
| 36,800 sf (Option 3) | 13744 | 150 | $25,700 | $2,646 | 9.7 |
| Averages: | 13250 | 354 | $24,037 | $5,059 | 7.0 |

***Annual Reduction in CO2-equivalent: 0.27 lb./sq.ft.-year; 10,083 lb./building-year***
***Increased Cost / lb. CO2-e reduction: $2.38***

## Low-rise Office Building

| Building Description | Total Annual KWh Saving | Total Annual Therms Saving | Incremental First Cost ($) | Annual Energy Cost Savings ($) | Simple Payback (Years) |
|---|---|---|---|---|---|
| 10,580 sf (Option 1) | 15208 | -47 | $9,132 | $3,920 | 2.3 |
| 10,580 sf (Option 2) | 16209 | -166 | $11,697 | $4,197 | 2.8 |
| 10,580 sf (Option 3) | 13474 | 110 | $17,967 | $3,745 | 4.8 |
| Averages: | 14964 | -34 | $12,932 | $3,954 | 3.3 |

***Annual Reduction in CO2-equivalent: 0.60 lb./sq.ft.-year; 6,334 lb./building-year***
***Increased Cost / lb. CO2-e reduction: $2.04***

## High-rise Office Building

| Building Description | Total Annual KWh Saving | Total Annual Therms Saving | Incremental First Cost ($) | Annual Energy Cost Savings ($) | Simple Payback (Years) |
|---|---|---|---|---|---|
| 52,900 sf (Option 1) | 93572 | -2 | $50,497 | $19,811 | 2.5 |
| 52,900 sf (Option 2) | 81081 | -10 | $58,250 | $21,837 | 2.7 |
| 52,900 sf (Option 3) | 74551 | 148 | $49,441 | $19,229 | 2.6 |
| Averages: | 83068 | 45 | $52,729 | $20,292 | 2.6 |

***Annual Reduction in CO2-equivalent: 0.72 lb./sq.ft.-year; 37,908 lb./building-year***
***Increased Cost / lb. CO2-e reduction: $1.39***

## Conclusions

Regardless of the building design, occupancy profile and number of stories, the incremental improvement in overall annual energy performance of buildings which exceed the 2008 Title 24 Building Energy Efficiency Standards by 15% appears cost-effective. However, each building's overall design, occupancy type and specific design choices may allow for a large range of incremental first cost and payback. As with simply meeting the requirements of the Title 24 energy standards, a permit applicant complying with the energy requirements of a green building ordinance should carefully analyze building energy performance to reduce incremental first cost and the payback for the required additional energy efficiency measures.